Electron scattering off ^{4}He with Three-Nucleon forces

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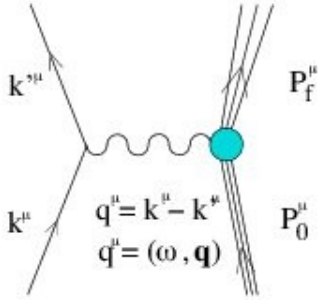
Outline:

- Brief summary of formalism for inclusive electron scattering
- Ingredients/methods of the performed ***ab initio*** calculation with realistic nuclear forces
- Results

Ab initio electron scattering



Inclusive process A(e,e')X

$$\frac{d^2\sigma}{d\Omega d\omega} = \sigma_M \left[\frac{Q^4}{\mathbf{q}^4} R_L(\omega, \mathbf{q}) + \left(\frac{Q^2}{2\mathbf{q}^2} + \tan^2 \frac{\theta}{2} \right) R_T(\omega, \mathbf{q}) \right]$$

$$R_L(\omega, \mathbf{q}) = \sum_f \left| \langle \Psi_f | \, \rho(\mathbf{q}) \, | \Psi_0 \rangle \right|^2 \delta \left(E_f - E_0 - \omega + \frac{\mathbf{q}^2}{2M} \right)$$

$$\underset{NR}{\rho}(\mathbf{q}) = \sum_k e^{i\mathbf{q}\cdot\mathbf{r}'_k} \frac{1 + \tau_k^3}{2}$$

Purpose → Investigate the effect of three-nucleon forces on $R_L(\omega, \mathbf{q})$

Nuclear forces employed: NN → AV18
NNN → UIX

Results with

LIT + EIHH

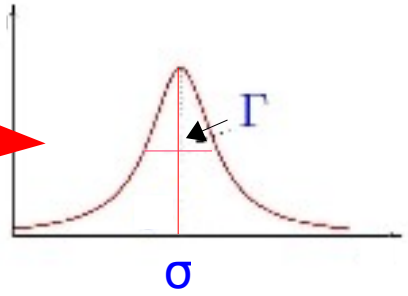
The Lorentz Integral Transform (LIT)

Efros, Leidemann, Orlandini, PLB 338 (1994) 13

$$R(\omega) = \sum_f \left| \left\langle \psi_f \left| \hat{O} \right| \psi_0 \right\rangle \right|^2 \delta(E_f - E_0 - \omega)$$

$$L(\sigma,\Gamma) = \int d\omega \frac{R(\omega)}{(\omega-\sigma)^2+\Gamma^2} = \langle \tilde{\psi} | \tilde{\psi} \rangle$$

$$(H - E_0 - \sigma + i\Gamma) \mid \tilde{\psi} \rangle = \hat{O} \mid \psi_0 \rangle$$



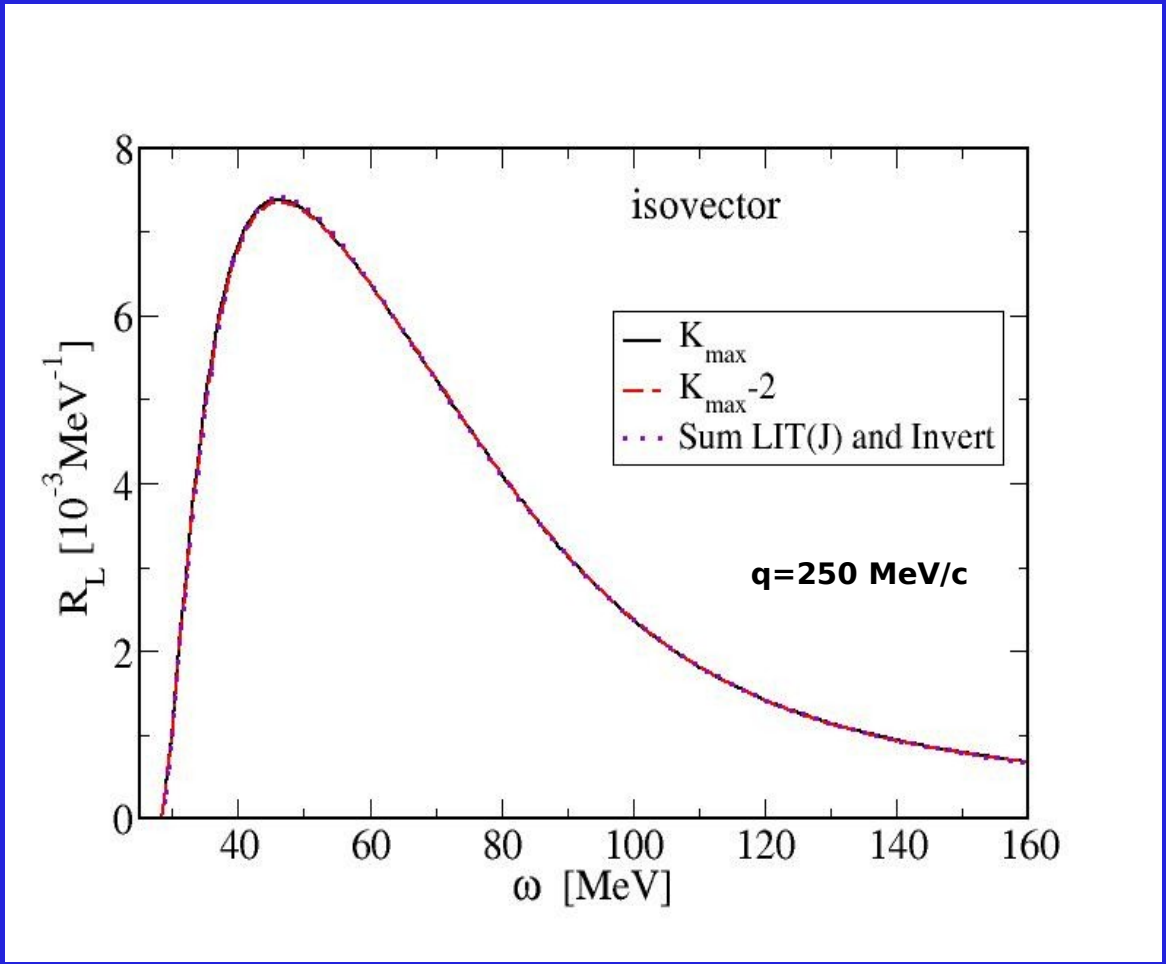
Calculation of ground state and of LIT L(σ,Γ) via expansions in Hyperspherical Harmonics (HH).

HH expansions have a very slow convergence rate for nuclear physics problems. Strong acceleration of convergence is obtained by the so-called Effective Interaction HH (EIHH).

EIHH: unitary transformation of bare interaction in a given model space leads to an effective interaction for model space; steady increase of model space up to the point that convergent ground-state/LIT results are obtained (similar to NCSM).
Barnea, W.L., Orlandini, PRC 61, 054001 (2000)

Precision of obtained results

- Convergence check of HH expansion
- Check of inversion



$R_L(\omega,q)$ of ^{4}He

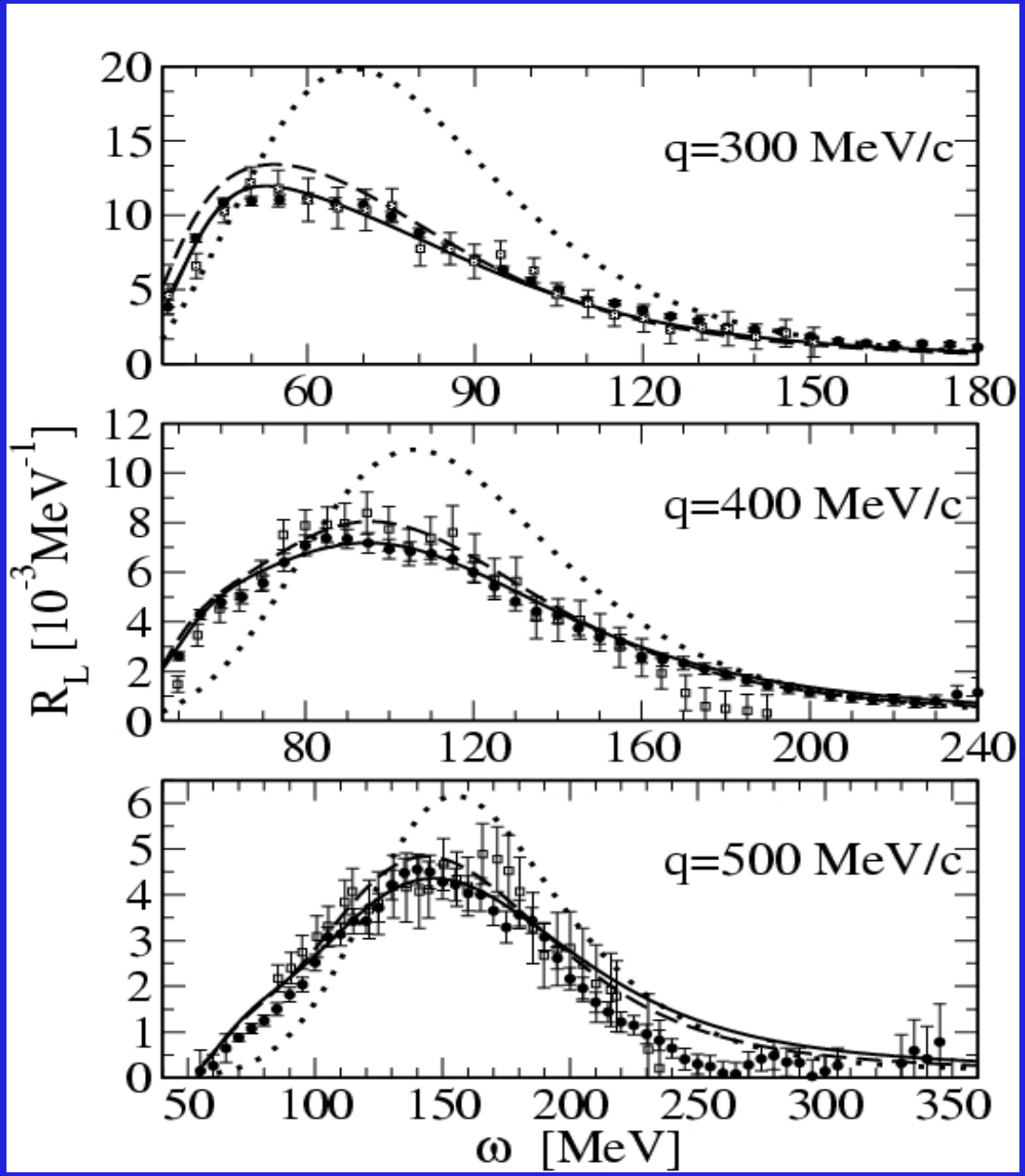
AV18

AV18 +UIX

PWIA

- **Large FSI effects**
- **10% reduction due to 3BF**
- **rather good agreement with data**

At q=500 MeV/c relativistic effects could become more important (see my poster on $R_{L/T}(\omega,q)$ of ^{3}He)

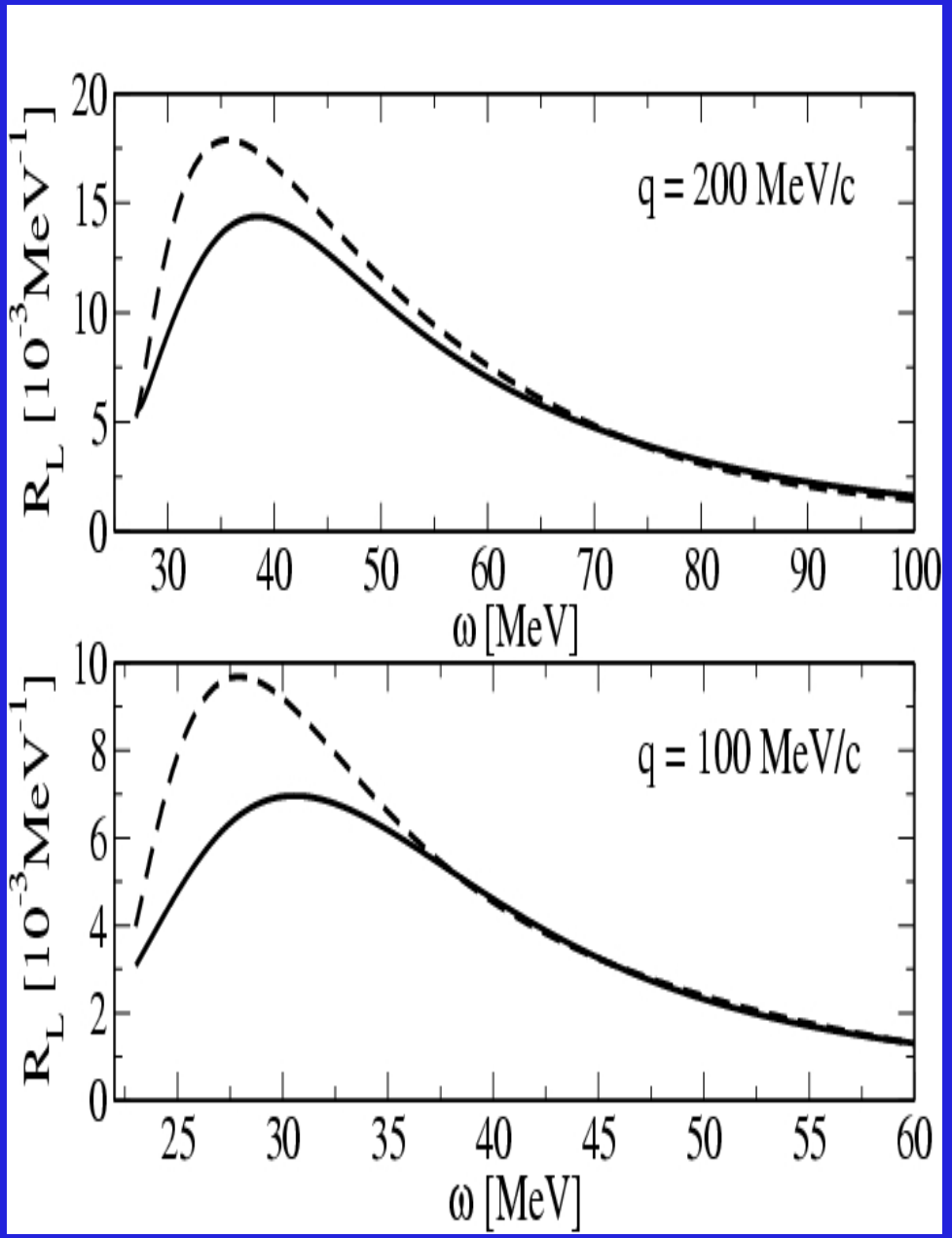


$R_L(\omega,q)$ of ^{4}He at lower q

AV18

AV18 +UIX

Large 3BF effects



3BF effects on peak position and peak height

	AV18	AV18+UIX	AV18	AV18+UIX	
q [MeV/c]	ω_p [MeV]	ω_p [MeV]	R_L [10^{-3}MeV^{-1}]	R_L [10^{-3}MeV^{-1}]	ΔR [%]
50	25	27	4.17	2.71	-35
100	28	30	9.70	6.90	-29
200	35	39	18.0	14.4	-20
300	54	53	13.4	12.0	-10
400	95	95	8.04	7.18	-11
500	143	147	4.82	4.35	-10

Experiments at low q would be needed!

Summary

- We have performed an *ab initio* calculation of $R_L(\omega,q)$ of ^{4}He with a realistic nuclear force (AV18+UIX)
- Rather strong FSI effects are found, even in peak region
- Important 3BF contribution, in particular at low q

Outlook

We are presently carrying out calculations with nuclear force AV18+TM' in order to find out if 3BF effect changes